

EXPERIMENTAL STUDY OF PHYSIOLOGICAL VARIATIONS IN URINARY
SODIUM AND POTASSIUM RELATED TO TIME ZONE CHANGES

J.P. Chevrier

(NASA-TT-F-16281) EXPERIMENTAL STUDY OF
PHYSIOLOGICAL VARIATIONS IN URINARY SODIUM
AND POTASSIUM RELATED TO TIME ZONE CHANGES
(Scientific Translation Service) 8 p HC
\$3.25

N75-23146

Unclass
20753

CSCL 06P G3/52

Translation of "Etude expérimentale des
variations physiologiques du sodium et du
potassium urinaires, liées au décalage
horaire", Comptes Rendus, Biologie, Vol.
167, No. 12, 1973, pp. 2014-2018.



Physiology

EXPERIMENTAL STUDY OF PHYSIOLOGICAL VARIATIONS IN URINARY
SODIUM AND POTASSIUM RELATED TO TIME ZONE CHANGES

J.P. Chevrier

Time zone disruptions lead to disturbances in circadian rhythms. Intercontinental airplane trips are a particularly recent example. However, the time zone shifts undergone during such flights are further complicated by associated factors such as fatigue involved in the trips, changes in temperature, diet and clothing, etc.

/2014

Experiments which have eliminated these associated factors are rare. Only Berkhout [1] and Klein and colleagues [2] have taken an interest in simulated experimental shifts, but on a very small number of subjects.

The equipment in the Laboratory of Medico-physiological Studies at Mont-de-Marsan** can be used for a simulation of instantaneous time zone shifts in eliminating factors associated with actual flights, due to a chamber with a controlled environment [3]. Numerous parameters were followed during these experiments, as much physiological as biological or psychological. From the former are obtained the results of this study.

* Numbers in the margin indicate pagination of original foreign text.

** The team consists of G. Chatelier, R. Falet, P. Galban, M. Gouars and M. Guillermin.

I. Procedure, Methods and Techniques. a. CONTROLLED ENVIRONMENTAL CHAMBER. — This method of experimentation allows the complete isolation of 4 subjects in an isolation chamber 10 X 10 m, consisting of 4 comfortable rooms and a bathroom. The possibilities offered by this chamber are very extensive since it is possible to vary a number of parameters (sound level, illumination, temperature, hygrometry, ventilation, level of CO₂). During this experiment the subjects were maintained in a comfortable environment.

b. SELECTION OF SHIFTS AND TIMES OF EXPERIMENTATION. — Four 20-day experiments, each involving 4 male subjects aged 20 to 45 years, allowed the subsection of each to 2 simulated and instantaneous shifts of 12 hours, separated by 8 days; one positive (from east to west), the other negative (from west to east).

c. SAMPLES AND ANALYSES. — The urine samples were taken at 7, 11, 15, 19 and 23 hours, whether on a real time schedule or a simulated one after shifting. The measurement of sodium and potassium by flame photometry yielded not only knowledge of the hourly elimination of each of these fractions daily, which were determined by the hour the samples were taken, but also of the total elimination in 24 hours.

/2015

II. Results. — The statistical evaluation of the results allowed the construction of Tables I to III, in which the results for diuresis are expressed in (m Val/hr). However, when positive or negative shifts are involved, only the latter are given because the obtained figures are very close.

III. Comments and Conclusions. First, it is appropriate to give limits to these experiments by noting that it was not possible to furnish the subjects with a calculated food ration

TABLE I. ELIMINATION OF Na^[+] AFTER NEGATIVE SHIFT OF L2 HOURS

Time zone periods		T	1 E	2 E	3 E	4 E	5 E	6 E	7 E	8 E
23-7 h	n	68	12	15	16	16	16	11	8	8
	x	4,84	4,53	5,35	5,75	5,46	5,74	3,85	2,69	3,54
	σ	2,24	2,28	2,07	2,68	2,25	3,10	1,62	-0,99	1,69
	t		0,44	-0,82	-1,41	-1,00	-1,34	1,40	2,67	1,59
7-11 h	n	67	7	12	12	12	12	12	8	6
	x	6,01	2,99	3,56	5,38	3,83	4,79	3,96	5,90	4,61
	σ	2,75	1,48	1,27	3,59	1,87	2,37	1,78	2,87	1,54
	t		2,80	3,02	0,70	2,63	1,41	2,49	0,10	1,23
11-15 h	n	68	7	12	12	12	12	8	8	6
	x	8,92	6,20	7,91	11,46	8,37	9,07	6,90	10,08	8,52
	σ	3,19	3,13	2,81	3,99	4,04	3,48	3,13	2,56	3,65
	t		2,16	1,04	-2,44	0,54	-0,15	1,67	-0,99	0,29
15-19 h	n	68	7	12	12	12	12	8	8	8
	x	8,60	5,44	6,71	7,99	8,02	6,85	5,90	7,56	5,86
	σ	3,18	1,85	2,08	3,33	2,33	2,99	1,12	2,51	1,92
	t		2,57	1,98	0,61	0,60	1,78	2,38	0,89	2,38
19-23 h	n	63	8	12	12	11	12	8	7	8
	x	7,68	7,26	6,87	7,81	8,07	6,42	6,31	5,54	7,14
	σ	2,79	2,03	2,86	2,93	2,47	3,02	1,90	1,95	5,43
	t		0,41	0,92	-0,14	-0,44	1,43	1,35	1,98	0,46

T represents the control-day mean, E the days following the shift (1E the first day, 2E the second day, etc.), \bar{n} is the number of observations, σ is the standard deviation of the mean, \bar{x} is the mean value calculated, t is the significance of the mean with respect to the corresponding control mean.

equivalent from one day to another and from one experiment to another. Dietary variations, thus, reverberate in the daily urinary output of each subject, but they result in hardly any change in mean rhythm calculated following the 4 basic experiments.

In examining one or another of the 3 tables of results, it is seen that often the responses furnished by each of the criteria considered are different. Thus, some individuals regain normal rhythm very rapidly, while the group of subjects attains

TABLE II. ELIMINATION OF K^+ AFTER NEGATIVE SHIFT OF 12 HOURS

Time zone periods		T	1 E	2 E	3 E	4 E	5 E	6 E	7 E	8 E
23-7 h	n	72	12	15	16	16	16	16	8	8
	\bar{x}	1,88	3,48	3,79	3,65	2,68	3,01	2,11	1,61	1,50
	σ	0,81	1,30	1,33	1,46	1,16	1,61	0,86	0,85	0,43
	t		-5,79	-7,39	-6,76	-3,34	-4,13	-1,02	0,89	1,31
7-11 h	n	68	7	12	12	12	12	12	8	7
	\bar{x}	3,75	2,24	2,29	2,92	2,40	2,86	2,91	3,75	2,30
	σ	1,43	0,58	0,72	2,30	1,12	1,46	1,09	1,76	1,10
	t		2,77	3,46	1,70	3,11	2,00	1,95	-0,38	2,61
11-15 h	n	68	7	12	12	12	12	8	8	8
	\bar{x}	4,35	3,03	3,38	4,53	3,10	3,41	3,51	3,95	3,62
	σ	1,50	1,02	1,57	1,55	1,25	0,87	1,57	1,10	1,32
	t		2,29	2,08	-0,37	2,61	2,13	1,50	1,11	1,24
15-19 h	n	68	7	12	12	12	12	8	8	8
	\bar{x}	3,69	4,03	3,59	4,23	3,38	3,66	3,25	2,88	3,38
	σ	1,54	1,88	1,52	2,25	1,45	1,57	1,07	0,34	1,06
	t		-0,54	0,20	-1,03	0,66	0,06	0,78	1,49	0,56
19-23 h	n	63	8	12	12	12	12	8	8	7
	\bar{x}	2,63	4,21	4,05	3,16	3,94	3,23	2,40	1,53	1,59
	σ	1,26	1,70	2,09	1,88	2,95	2,51	0,80	0,77	0,74
	t		-3,22	-3,18	-1,22	-2,55	-1,24	0,51	2,42	2,15

this result only later. By reference to the lack of statistical significance, recuperation time thus obtained is average with respect to the two preceding criteria.

It is this disappearance of significance which was finally taken throughout the entire study as the principal criterion for a return to control biorhythm.

With regard to the negative shift, the recovery of control biorhythm was followed for 8 days in 16 subjects. Readaptation came about after 5 to 7 days of testing; at the 5th day for the cation Na^+ , the 6th day for the cation K^+ , and the 7th day for diuresis.

/2017

With respect to sodium and diuresis, it is necessary to note that 2 subjects regained their control rhythms at the 3rd

day; they were young men of 23 and 25 years, respectively.

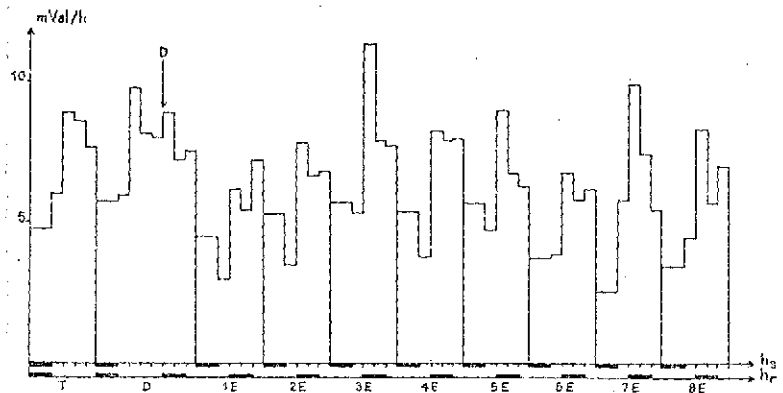


Figure 1. Time course of changes in circadian rhythm of Na^+ elimination after negative shift of 12 hours. D represents the day of the shift (at 21 hours the subjects started their day over at 9 a.m.). h_s represents the simulated time zone which the subjects underwent and h_r the real time zone. The superimposed segments indicate the nocturnal periods, real and simulated.

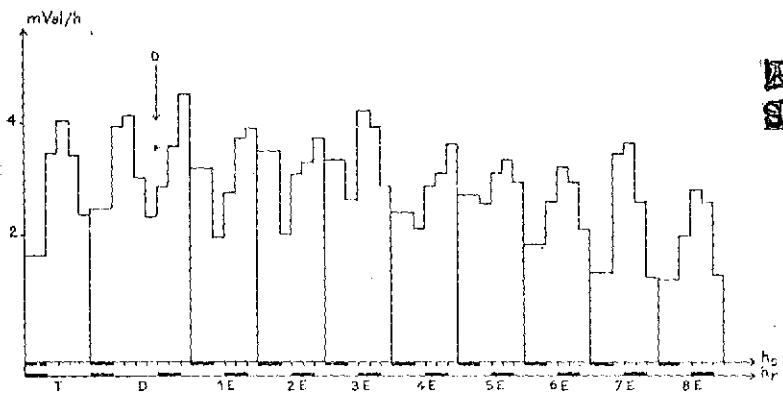


Figure 2. Time course of changes in circadian rhythm of elimination of K^+ after negative shift of 12 hours.

Given the identical results of the two types of shifts, it can be concluded that whatever the shift, recovery takes place in 5 to 7 days. Sodium appears to be the parameter which regains control rhythm most rapidly, faster than potassium and diuresis in every case.

If daily elimination is considered, it is seen that this elimination is scarcely influenced by the so-called time zone shift; despite the variations in the mode of living. In fact,

from the 1st or the 2nd day of testing, daily elimination did not show significant differences from control values for elimination. The variations in rhythm during daily routine thus do not influence total elimination over 24 hours. /2018

TABLE III. DAILY TOTAL ELIMINATION AFTER NEGATIVE SHIFT OF 12 HOURS.

Parameters		T	1 E	2 E	3 E	4 E	5 E	6 E	7 E	8 E
Diuresis in ml.	n	63	6	16	16	16	16	16	8	8
	x	1260	1383	1386	1417	1239	1402	1281	1069	1265
	σ	308	224	379	355	252	229	354	290	512
	t		-0,95	-1,39	-1,76	0,26	-1,73	-0,23	1,07	-0,64
Na ⁺ in mVal	n	63	6	16	16	16	16	16	8	8
	x	174,25	156,03	156,36	183,13	157,71	183,66	152,69	135,66	146,82
	σ	52,46	34,49	37,41	32,99	23,15	44,69	35,76	32,91	61,27
	t		0,83	1,28	-0,65	1,23	-0,66	1,55	2,03	1,37
K ⁺ in mVal	n	62	6	16	16	16	16	16	8	8
	x	72,86	79,85	83,03	85,18	66,56	69,03	67,86	59,67	67,58
	σ	17,35	12,96	23,85	20,21	14,14	17,12	10,94	13,54	27,61
	t		-0,96	-1,94	-2,46	1,35	0,79	1,10	2,07	0,75

In conclusion, a time zone shift of 12 hours, in either direction, leads to a disturbance in normal circadian rhythm of urinary parameters under study. A 7-day period of recovery is necessary for a complete return to control biorhythms, while the shift has practically no effect on elimination over 24 hours.

REFERENCES

1. Berkhout, J. Simulated time-zone shifts and performance ability: behavioral electroencephalographic and endocrine effects of transient alterations in environmental phase - AGARD, Conf. Proc. Fr., 1970, No. 74, p. 6-69.
2. Klein, K.E., H. Bruner, H. Holtmann, H. Rehme, J. Stölze, W.D. Steinhoff and H.M. Wegmann, Aerospace Med. U.S.A., t. 41, No. 2, 1970, p. 125.
3. Chevrier, J.P. Experimental study of physiological variations related to time zone shifts: Changes in biological urinary parameters. Thèse de Biologie humaine, Vol. 10, 1973, p. 88. Bordeaux. Ronsot.

Translated for National Aeronautics and Space Administration under contract No. NASw 2483, by SCITRAN, P. O. Box 5456, Santa Barbara, California, 93108.